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Experimental Analysis on Improving Concrete Quality by Using – SF Micro Silica

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Abstract-Concrete is the most important Engineering material in construction industry because of its inherent strength properties. However the addition of some other materials may change the properties of concrete. Mineral addition which are also used as mineral admixtures have been used with cement for many years. Micro silica, is a non crystalline material also called as Silica Fumes (SF) is produced in electric arc furnace as a by production of elemental silicon or alloy containing silicon. Micro silica was initially viewed as cement replacement material and in some area it is generally used as replacement material as silica fume in pozzolanic admixtures. The silica gives protection against embedded steel in porous water. It increases the compressive strength of concrete up to 20000 psi (140 Mpa). The compressive strength of concrete cubes of grade M40, M50 grades are increased by 10% to 30% in replacement of micro silica. The Ceraplast is a strength improving admixture used for ultimate strength, workability and admixtures are used with concrete to find the compressive strength and split tensile strength for M40, M50 grade cylindrical cubes. The study of silica gives the advantages such as its increase in durability, reduces concrete permeability, and improves resistance to corrosion.

Index Terms-SF, Micro silica, (M40, M50) grades of concrete, Ceraplast, admixtures, compressive strength, split tensile strength, workability

1 Introduction

High-strength and High-performance the concrete are being widely used throughout the world and it is necessary to produce them to reduce the water binder ratio and increase the binder content. High-strength concrete governs good abrasion, impact and cavitation resistance. Today High-strength concrete are used in structures since it results in economical advantages. Recently applications of high strength concrete are more in high-rise buildings, long span bridges and some special structures. Major application of high strength concrete in tall structures have been in columns and shear walls, which resulted in decreased dead weight of the structures and increased the amount of the rental floor space in the lower stories. In future, high range water reducing admixtures (super plasticiser) will open up new possibilities for use of these materials as a part of cementing materials in concrete to produce very high strengths, as some of them are more finer than cement.

2 Importance for the Study

Plain cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks, poor tensile strength eventually lead to brittle fracture of concrete. The development of such micro cracks is the main cause of inelastic deformation. Addition of small closely spaced and uniform micro silica or silica fumes with concrete would act as crack arrester and would substantially improve the static and dynamic properties. Most of the concrete has less durability properties. To remove such properties in concrete ceraplast admixtures are used in the concrete. Admixtures also give strength and workability to the concrete. Hence this experimental analysis helps for the following studies:

- To study the behaviour of silica fumes in concrete.
- To study the compressive strength of conventional and silica fumed concrete cubes of M40 and M50 Grade.
- To study the split tensile strength of conventional and silica fumed concrete cylinders of M40 and M50 Grade.

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3 Materials and Methods

Silica fume

Ceraplast

3.1 Silica fume

The American Concrete Institute (ACI) defines silica fume as “very fine non-crystalline silica” produced in electric arc furnaces as a by-product in the production of elemental silicon or alloys containing silicon (ACI 116R). It is usually a gray colored powder, somewhat similar to Portland cement or some fly ashes. Silica fume is usually categorized as a supplementary cementitious material. This term refers to materials that are used in concrete in addition to Portland cement.

3.1.1 Effect of silica fume in fresh concrete

Increased Cohesion - Fresh concrete made with silica fume is more cohesive and therefore less prone to segregation than concrete without silica fume. To offset this increased cohesion when placing, silica-fume concrete is typically placed at 40 to 50 mm greater slump than concrete without silica fume in the same placement. The main benefit from increased cohesion can be seen in shotcrete, whether it is for new construction, repair of existing structures, or ground support in tunnelling operations. Using silica fume in shotcrete allows for greater thickness of shotcrete layers, particularly when shooting overhead, and a significant reduction in rebound.

3.1.2 Consequences

- Reduced bleeding
- Enhanced mechanical properties

Reduced Bleeding

Because of the very high surface area of the silica fume and very low water content of silica-fume in concrete, there will be very less bleeding. Once a silica fume content of about five percent is reached, there will be no bleeding in most concretes. Concrete bleeds as the heavier components (cement and aggregates) settle under the influence of gravity before the concrete stiffens.

Enhanced Mechanical Properties

Silica fume gained initial attention in the concrete market place because of its ability to produce concrete with very high compressive strength.

3.2 Admixtures

Ceraplast 300

Ceraplast is a resin based air entraining admixture which principally improves workability and plasticity of mortars used for plastering and masonry. It is a liquid mortar plasticizer. It entrains microscopic air bubbles, which makes the mortar easier to work and spread. These pockets of air also have the effect of interrupting the formation of capillary channels so that the passage of water through the mortar is minimized. The volume of these air bubbles is also sufficient to absorb the internal stresses set up by the alternate freezing and thawing of entrapped air.

3.2.1 Functions

Ceraplast 300 resin is a high performance new generation super plasticiser cum retarding admixture which lowers the surface tension of water and makes cement particles hydrophilic, resulting in excellent dispersion as well as controls the setting of concrete, depending on dosage. This increases the workability of concrete drastically and also facilitates excellent retention of workability. The workability offered at a lower water water-cement ratio eliminates chances of bleeding, increased workability, retention allows increased travel time.

3.2.2 Uses and Benefits of Silica Fume Concrete

- Increased cohesiveness of the fresh concrete, which can lead to improved handling characteristics
- Curing can start earlier as there is no need to wait for bleed water to dissipate.

3.3 Characteristics of Hardened Silica fume Concrete

- Lower permeability and improved durability (due to the fine particle size and reactivity of SF).
- Greater resistance to abrasion and impact than conventional concretes of similar strength grade.
- Compressive strengths in excess of 60 N/mm2 are easily achieved.
- Higher flexural strength and modulus of elasticity than conventional concretes of equal compressive strength is obtained.

3.3.1 Silica Fume and Hardened Concrete

The overall resistance of silica-fume concrete to attack by an aggressive chemical is not significantly different from that of conventional Portland cement concrete. However, the reduced permeability of silica-fume concrete may extend the life of a concrete structure or extend the time between repairs, simply by slowing down the rate of the attack.

3.3.2 Micro Filler Effect

SF is an extremely fine material, with an average diameter 100 times finer than cement. At a typical dosage of 8% by weight of cement, approximately 100,000 particles for each grain of cement will fill the water spaces in fresh concrete.

4 Applications

4.1 Corrosion Resistance

The reduced permeability of SF provides protection against intrusion of chloride ions thereby increasing the time taken for the chloride ions to reach the steel bar and initiate corrosion. In addition, SF concrete has much higher electrical resistivity compared to OPC concrete thus slowing down the corrosion rate.

4.2 Shot Crete

SF (Silica Fume) is used in shotcrete whether produced by wet or dry process, to reduce rebound loss, to increase application thickness per pass, improve resistance to wash out in marine construction or wet areas and to improve the properties of hardened shotcrete.

4.3 Heat Reduction

By replacing cement with SF and observing the efficiency factor of SF, a lower rise maximum temperature and temperature differential will take place for concrete with the same strength.

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5 Mix Design

Concrete mix design is an art of fixing the preparation of the various ingredient of concrete namely, fine aggregate, coarse aggregate, cement and water. It is a trial and error method of setting the various values in order to attain the maximum strength with the given proportion. The report has followed the **Erntroy and Shacklockmethod** for the mix design and the mix design has been done for M40 and M50 grades of concrete.

6 Analysis

6.1 COMPRESSIVE STRENGTH

Table 1 M40 - Conventional Concrete Compressive Strength

Specimen No	Grade of Concrete	Water Ratio	Admixture Ratio (Ceraplast)	Compressive Strength at 7 days in MPa	Average strength in MPa	Compressive Strength at 28 days in MPa	Average strength in MPa
C-1	M-40	0.35	0.10	25.11		43.11	
C-2	M-40	0.35	0.10	24.00	25.23	42.88	42.74
C-3	M-40	0.35	0.10	22.44		42.23	

Fig.1 Compressive strength of concrete before replacement of cement by micro silica

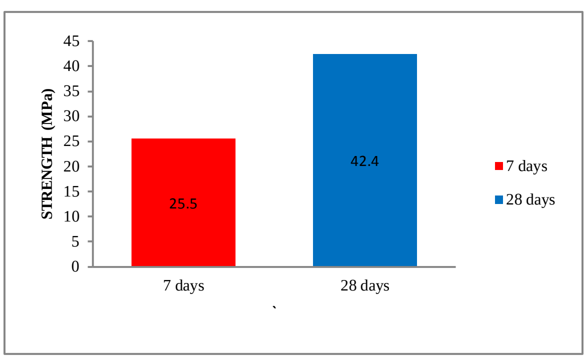
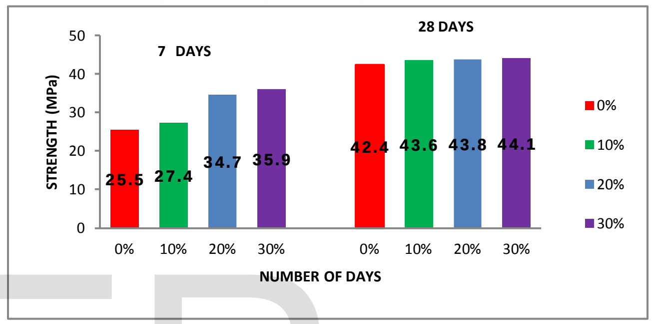


Table 2 M40 - Concrete Cubes With 30% Replacement of Cement by Micro silica

Specimen No	Grade of Concrete	Water Ratio	Admixture Ratio (Ceraplast)	Compressive Strength at 7 days in MPa	Average strength in MPa	Compressive Strength at 28 days in MPa	Average strength in MPa
C-1	M-40	0.35	0.10	36.0		44.2	
C-2	M-40	0.35	0.10	35.3	35.9	44.0	44.1
C-3	M-40	0.35	0.10	36.4		44.2	

Fig.2 the compressive strength has been increased by replacing cement with SF

Fig.3 COMPARISON OF COMPRESSIVE STRENGTH FOR 10% TO 30% REPLACEMENT OF CEMENT BY SF FOR M40 GRADE CONCRETE



6.1.2 For M50 Grade Concrete

Table 3 M50 - Conventional concrete Compressive strength

Specimen No	Grade of Concrete	Water Ratio	Admixture Ratio (Ceraplast)	Compressive Strength at 7 days in MPa	Average strength in MPa	Compressive Strength at 28 days in MPa	Average strength in MPa
C-1	M-50	0.35	0.10	38.3		51.7	
C-2	M-50	0.35	0.10	38.7		51.3	
C-3	M-50	0.35	0.10	38.5	38.5	51.5	51.5

Table 4 M50 - Concrete Cubes With 30% Replacement of Cement by Micro silica

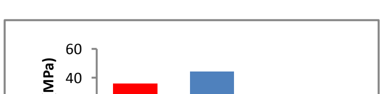


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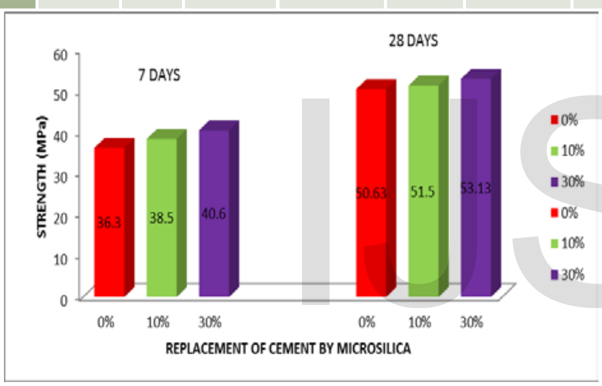
Fig.4 COMPARISON OF COMPRESSIVE STRENGTH FOR 10% TO 30% REPLACEMENT OF CEMENT BY SF FOR M50 GRADE CONCRETE

Specimen No	Grade of Concrete	Water Ratio	Admixture Ratio (Ceraplast)	Compressive Strength at 7 days in MPa	Average strength in MPa	Compressive Strength at 28 days in MPa	Average strength in MPa
C-1	M-50	0.35	0.10	40.4	40.6	53.4	53.13
C-2	M-50	0.35	0.10	39.8		52.8	
C-3	M-50	0.35	0.10	41.4		53.2	



6.2 SPLIT STRENGTH

6.2.1 For M40 Grade Concrete

Table 5 M40 - Concrete Split Tensile Strength

Specimen No	Grade of Concrete	Water Ratio	Admixture Ratio (Ceraplast)	Split Tensile Strength at 7 days in MPa	Average strength in MPa	Split Tensile Strength at 28 days in MPa	Average strength in MPa
C-1	M-40	0.35	0.10	3.6	3.5	5.4	5.4
C-2	M-40	0.35	0.10	3.4		5.4	

Table 6 M40 - Concrete Cylinders With 30% Replacement of Cement by Micro silica

Specimen No	Grade of Concrete	Admixture Ratio (Ceraplast)	Split Tensile Strength at 7 days in MPa	Average strength in MPa	Split Tensile Strength at 28 days in MPa	Average strength in MPa
C-1	M-40	0.10	5.1	5.0	6.4	6.3
C-2	M-40	0.10	4.9		6.2	

Fig.5 M40 Grade Concrete Split Tensile Strength

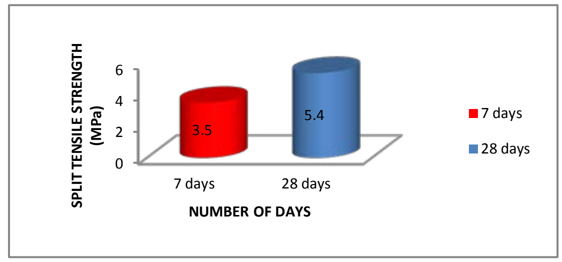


Fig.6 M40 Grade -30% Replacement of Cement by Micro silica

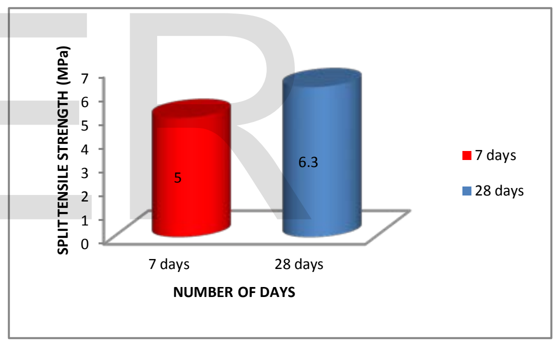
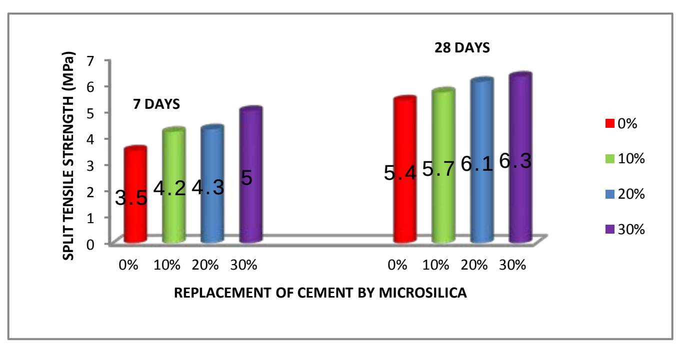


Fig.7 COMPARISON OF SPLIT TENSILE STRENGTH FOR 10% TO 30% REPLACEMENT OF CEMENT BY SF FOR M40 GRADE CONCRETE



6.2.2 For M50 Grade Concrete

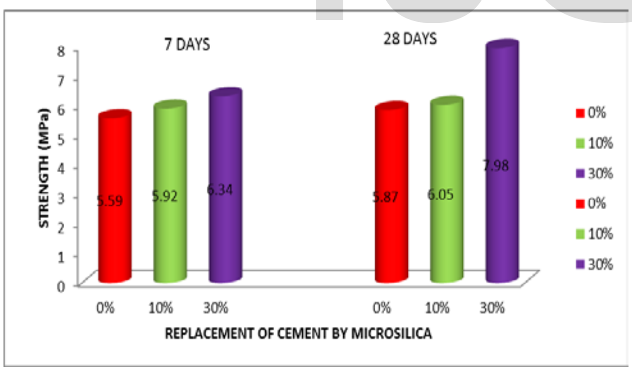
Table 7 M50 - Conventional split tensile strength

Specimen No	Grade of Concrete	Water Ratio	Admixture Ratio (Cerasplast)	Split Tensile Strength at 7 days in MPa	Average strength in MPa	Split Tensile Strength at 28 days in MPa	Average strength in MPa
C-1	M-50	0.35	0.10	5.57	5.59	5.90	5.87
C-2	M-50	0.35	0.10	5.60		5.85	

Table 8 M50 - Concrete Cylinders With 30% Replacement of Cement by Micro silica

Specimen No	Grade of Concrete	Water Ratio	Admixture Ratio (Cerasplast)	Split Tensile Strength at 7 days in MPa	Average strength in MPa	Split Tensile Strength at 28 days in MPa	Average strength in MPa
C-1	M-50	0.35	0.10	6.20	6.34	7.90	7.98
C-2	M-50	0.35	0.10	6.47		8.05	

Fig.8 M50- Grade Combined Split Tensile Strength



7 Comparison of M40 and M50 Grade Concrete Strengths

7.1 Comparison of Compression Strength

Fig.9 Comparison of M40 and M50 Grade Compressive Strength for 7 Days

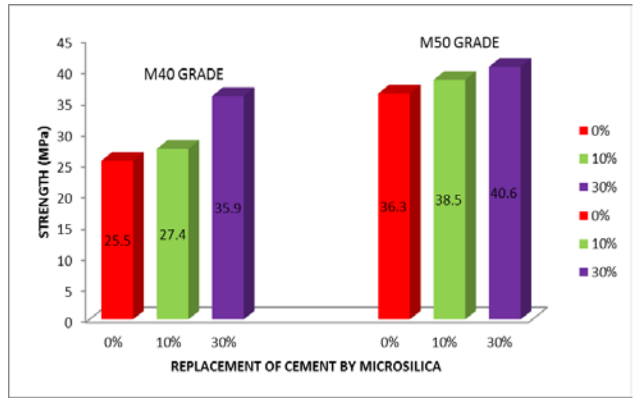
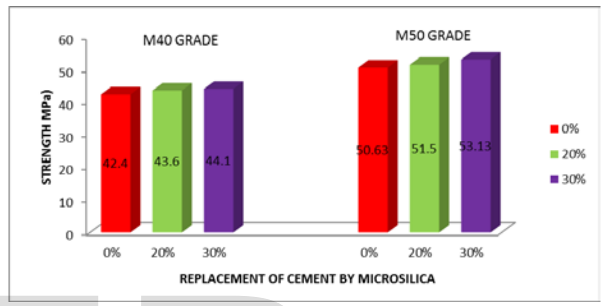


Fig.10 Comparison of M40 and M50 Grade Compressive Strength for 28 days



7.2 Comparison of Split Tensile Strength

Fig.11 Comparison of M40 and M50 Grade Concrete Split Tensile Strength for 7 Days

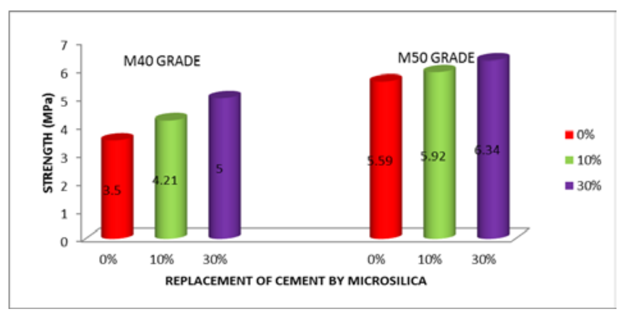
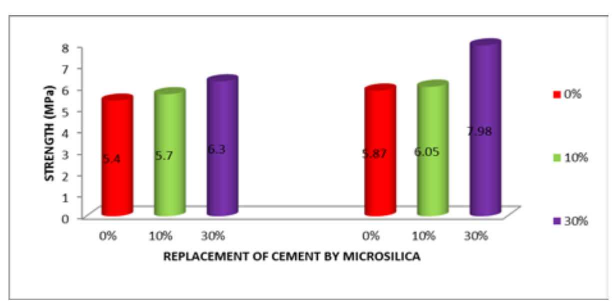


Fig.12 Comparison of M40 and M50 Grade Concrete Split Tensile Strength for 28 Days



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8 CONCLUSION

Silica fume increases the strength of concrete more by 25%. Silica fume is much cheaper than cement therefore it is very important from economical point of view. It is a material which may be a violent of air pollution, as this is a byproduct of some Industries. Use of micro silica with concrete decreases the air pollution. Silica fume also decreases the voids in concrete. Addition of silica fume reduces capillarity, absorption and porosity because fine particles of silica fume reacts with lime present in cement.

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